

**STUDY GUIDE**

**PRELIMINARY  
AND  
PRIMARY TREATMENT**

**INTRODUCTION  
AND  
ADVANCED**

**SUBCLASS A**

WISCONSIN DEPARTMENT OF NATURAL RESOURCES  
BUREAU OF INTEGRATED SCIENCE SERVICES  
P. O. BOX 7921  
MADISON, WI 53707

JANUARY 1994 EDITION

## **PREFACE**

This operator's study guide represents the results of an ambitious program. Operators of wastewater facilities, regulators, educators and local officials, jointly prepared the objectives and exam questions for this subgrade.

The objectives in this study guide have been organized into modules, and within each module they are grouped by major concepts.

### **HOW TO USE THESE OBJECTIVES WITH REFERENCES**

In preparation for the exams, you should:

1. Read all the objectives that apply to the grade level desired and write down the answers to the objectives that readily come to mind.
2. Use the references at the end of the study guide to look-up answers you don't know. This one set of references covers all of the objectives.
3. Write down the answers found in the references to those objectives you could not answer from memory.
4. Review all answered objectives until you can answer each from memory.

**IT IS ADVISABLE THAT YOU ATTEND SOME FORM OF FORMAL TRAINING IN THIS PROCESS BEFORE ATTEMPTING THE CERTIFICATION EXAM.**

### **Choosing A Test Date**

Before you choose a test date, consider the training opportunities available in your area. A listing of training opportunities and exam dates can be found in the annual DNR "Certified Operator," or by contacting your DNR District operator certification coordinator.

# INTRODUCTION

## INTRODUCTION TO PRELIMINARY AND PRIMARY TREATMENT

---

### MODULE A: PRINCIPLE, STRUCTURE AND FUNCTION OF PRELIMINARY TREATMENT

---

#### CONCEPT: PRINCIPLE OF PRELIMINARY TREATMENT

1. Identify four different types of preliminary treatment, and describe the purpose of each.
2. Define the composition of grit.

#### CONCEPT: STRUCTURE AND FUNCTION OF PRELIMINARY TREATMENT

3. Explain the function of grit removal systems.
  4. Describe three types of grit removal Systems.
  5. Describe the structure and function of manually cleaned bar screens.
  6. Describe the structure and function of automatically cleaned bar screens.
  7. Discuss the function and operation of comminutors.
  8. Discuss the function and operation of barminutors.
- 

### MODULE B: OPERATION AND MAINTENANCE OF PRELIMINARY TREATMENT

---

#### CONCEPT: OPERATION OF PRELIMINARY TREATMENT

9. Discuss the situations where chemical pretreatment may be necessary to protect downstream processes.
10. Discuss alternative grinding systems to the use of comminutors and barminutors.

11. Identify where grit collects when it is not caught in the grit chamber.
12. Explain why grit and screenings should be contained and properly disposed of.
13. Describe what determines the scheduling of disposal of grit and screenings, and what might cause increases in grit/screenings production.
14. Identify two purposes for aeration in grit chambers.
15. Describe how to properly dispose of debris generated from preliminary treatment.
16. Compare the impact on preliminary and primary treatment of septic tank contents vs. holding tank contents.
17. Describe how an operator can protect downstream processes if the comminutor is shut-down for maintenance or repair.
18. Explain the necessity of good ventilation around an aerated grit chamber, especially, when influent is septic or anaerobic.
19. Describe the impact of rodding and jetting sewers on preliminary and primary treatment.

**CONCEPT: MAINTENANCE OF PRELIMINARY TREATMENT**

20. Describe the possible affects on flow measurement and the collection system if bar screens are not regularly cleaned.
21. Discuss where maintenance schedules for automatically cleaned bar screens are located.
22. State the items to inspect and maintain regularly in comminutors and barminutors.
23. Explain what would determine the frequency for sharpening and/or replacing of comminutor teeth.
24. Explain what should be included in a preventive maintenance schedule for grit removal and grit chamber aeration systems.
25. Discuss the purpose of the comminutor rock sump, and suggest maintenance intervals.
26. Explain where the lubrication procedure for comminutors would be located.

---

---

## **MODULE C: MONITORING, TROUBLESHOOTING AND SAFETY IN PRELIMINARY TREATMENT**

---

---

### **CONCEPT: MONITORING PRELIMINARY TREATMENT**

27. Describe how to determine if too much (or too little) material is settling-out in a grit chamber.
28. Explain how to measure the amounts of grit removed from a system.
29. Describe how to determine organic content in grit, and state normal range of values.

### **CONCEPT: TROUBLESHOOTING PRELIMINARY TREATMENT**

30. Discuss the operational changes to consider in event of a power outage in preliminary treatment.
31. List three potential problems that could be caused by improper use of chlorine in pretreatment.
32. Discuss the causes and corrective actions for odor problems at plant headworks.
33. Describe the potential problems and suggest corrective actions if:
  - A. Too little grit is being caught in grit chamber
  - B. Too much organic material is settling in grit chamber

### **CONCEPT: SAFETY IN PRELIMINARY TREATMENT**

34. Describe why there is an increased risk of disease when working with grit and screenings.
35. Explain why odor problems at plant headworks may constitute a health hazard as well as being a nuisance.
36. Discuss where the possibility of confined space entry areas would be while performing maintenance on bar screens, grinders and grit tanks.

37. List the procedures for confined space entry required to perform maintenance tasks in a confined area.
38. Describe the safety hazards related to maintenance of automatically cleaned bar screens.
39. Explain why geared-down machines are considered more dangerous than high-speed equipment.

---

---

#### **MODULE D: PRINCIPLE AND OPERATION OF PRIMARY TREATMENT**

---

---

##### **CONCEPT: PRINCIPLE OF PRIMARY TREATMENT**

40. Explain the main purpose of primary treatment.
41. Describe two ways to achieve primary treatment.
42. Explain why primary treatment is more important if followed by trickling filters or rotating biological contactors, than if followed by an activated sludge process.
43. Describe the principle of primary settling as related to solids settling.

##### **CONCEPT: STRUCTURE AND FUNCTION OF PRIMARY TREATMENT**

44. Discuss the components of circular and rectangular primary clarifiers, and identify the following parts:
  - A. Influent Baffle
  - B. Scum Trough
  - C. Effluent Weir
  - D. Scum Baffle
  - E. Sludge Hopper
  - F. Sludge Ploughs
  - G. Flight and chain
  - H. Shoes
45. Identify the common types of pumps suitable for pumping primary sludge, and describe how they work.

---

---

## MODULE E: OPERATION AND MAINTENANCE OF PRIMARY TREATMENT

---

---

### CONCEPT: OPERATION OF PRIMARY TREATMENT

46. Explain why it is better, if possible, to fill a primary clarifier with clean water at start-up than with raw sewage.
47. Describe how to determine if grit and heavy solids are building up in the sludge hopper of the primary clarifier.
48. Discuss the ways of preventing accumulation of grease, grit, and heavy solids, in sludge hoppers and sludge lines.
49. Describe the purpose and operation of scum removal systems.
50. List the appropriate methods of dealing with primary tank scum skimmings.
51. Explain the impact of the following on sludge pumping:
  - A. Solids Loading Rate.
  - B. Automatic Sludge Removal Systems
  - C. A Full Anaerobic Digester
52. List the conditions that indicate sludge pumping should be done more frequently.
53. State the range of values for percent removal of suspended solids expected from primary treatment.
54. Describe the equipment to use to determine if primary sludge is being completely removed.
55. Describe how actual detention time compares with theoretical detention time.
56. State the recommended detention time for primary sedimentation tanks.
57. Discuss the impact of solids content and volatile solids of primary sludge on the operation of anaerobic digesters.
58. List the methods of changing sludge pumping rates.
59. List the reasons causing how a piston pump to be running, but not pumping sludge.



60. List the indicators that an operator can use to tell when to shut-off the sludge pump.
61. Describe the function of a torque limiting device, and explain the consequences if it is tampered with when taken out of service.
62. List the items an operator should consider when operating a primary clarifier during cold weather.

**CONCEPT: MAINTENANCE OF PRIMARY TREATMENT**

63. Describe the items to consider in maintenance inspection of the following:
  - A. Clarifier Chains
  - B. Flights
  - C. Shoes
  - D. Bottom Rails
  - E. Gear Reducers
64. List the maintenance steps for centrifugal pumps, positive displacement pumps, progressive cavity pumps, and diaphragm pumps.
65. Develop a checklist to follow prior to pumping sludge with a positive displacement pump.
66. List the places to check for wear on sludge collectors.
67. Discuss the lubrication and gear coating maintenance of the primary drive mechanism.
68. List the items to consider when inspecting primary weirs and baffles for proper function.
69. Explain why it is necessary to adjust the tension of the clarifier chain after start-up and state how the adjustment is done.

---

---

## MODULE F: MONITORING AND TROUBLESHOOTING OF PRIMARY TREATMENT

---

---

### CONCEPT: MONITORING IN PRIMARY TREATMENT

- 70. List two laboratory tests used to evaluate primary treatment.
- 71. List the steps in the procedure for testing sludge for volatility and solids content.

### CONCEPT: TROUBLESHOOTING IN PRIMARY TREATMENT

- 72. Describe the impact on anaerobic digestion if primary sludge pumps are routinely left running too long.
- 73. Explain why progressive cavity sludge pumps:
  - A. Should not run dry
  - B. Should not be run against a closed head
- 74. Describe what can happen if a positive displacement pump is pumping against a closed head.
- 75. Describe normal sludge concentration and the affect on sludge quality of sludge pumping rates.
- 76. Describe what can happen if a piston pump is pumping to a fixed cover digester, and the overflow and pressure relief valves are not functioning properly.
- 77. Explain why operators should take precautions when turning-off valves not to trap sludge between two valves.
- 78. Define "coning" in relation to pumping sludge, and suggest appropriate preventive action.
- 79. Explain why an operator should be aware of groundwater levels and the functioning of relief valves before dewatering clarifiers.

80. Describe the possible impact on primary treatment of the following:
- A. Poor Quality Anaerobic Digester Supernatant
  - B. Excessive Backwashing of Tertiary Filter
  - C. Returning Secondary Sludge From a Trickling Filter Plant To Head of Primary
  - D. Waste Activated Sludge Sent To Influent Wet Well
81. Describe the impact of the following on primary treatment:
- A. Poor Grit Removal
  - B. Low Flows and Hot Weather
  - C. Waste Solids Returned To Plant Headworks
  - D. Inflow and Infiltration
  - E. Short Circuiting
82. Identify the possible causes and corrective actions for the following:
- A. Poor Removal of Settleable Solids
  - B. Sludge and Primary Effluent Dark and Odorous ( $H_2S$ )
  - C. Sludge Pumped To The Digester Is Too Thin
83. Identify possible causes and corrective actions of:
- A. Frequent Shear Pin Failure
  - B. Broken Chain Or Sprockets
  - C. Noisy Drive Mechanism

---

---

## **MODULE G: SAFETY AND CALCULATION OF PRIMARY TREATMENT**

---

---

### **CONCEPT: SAFETY IN PRIMARY TREATMENT**

84. Explain why air should be checked and good ventilation provided when working on sludge pumps and valves.
85. Explain the importance of having an alternative way of shutting-off the power to a piston pump.
86. List the safety procedures when opening covers of piston pump check valves.

**CONCEPT: CALCULATION OF PRIMARY TREATMENT**

87. Given data, calculate the percent removal of suspended solids or BOD.
88. Given data, calculate the average detention time for a primary tank.
89. Given data, calculate the gallons of sludge pumped when running time and capacity of pump are known.
90. Given data, calculate solids loading to a primary clarifier.



**ADVANCED**

## **ADVANCED PRELIMINARY AND PRIMARY TREATMENT**

---

### **MODULE A: PRINCIPLE, STRUCTURE AND FUNCTION OF PRELIMINARY TREATMENT**

---

#### **CONCEPT: PRINCIPLE OF PRELIMINARY TREATMENT**

1. List the most important operational considerations in selecting a preliminary treatment system.
2. Discuss the reasons for pre-chlorination of wastewater influent.

#### **CONCEPT: STRUCTURE AND FUNCTION OF PRELIMINARY TREATMENT**

3. Describe the types of equipment used in preliminary systems to control debris entering the treatment plant.
  4. Discuss the purpose and methods of grit washing.
  5. Discuss the reason for grinders and screening in preliminary treatment.
- 

### **MODULE B: OPERATION AND MAINTENANCE OF PRELIMINARY TREATMENT**

---

#### **CONCEPT: OPERATION OF PRELIMINARY TREATMENT**

6. Explain why the flow velocity in a horizontal grit chamber should be approximately one foot per second.
7. Explain why flow rates in sewers should exceed two feet per second.
8. Discuss the types of chemicals and their purpose that might be used for pretreatment.

**CONCEPT: MAINTENANCE OF PRELIMINARY TREATMENT**

9. Describe the maintenance needed for comminutors and barminutors.
10. Describe the impact on comminutor maintenance if it is located ahead of the screening and grit removal equipment.

---

**MODULE C: MONITORING, TROUBLESHOOTING AND SAFETY IN PRELIMINARY TREATMENT**

---

**CONCEPT: MONITORING OF PRELIMINARY TREATMENT**

11. Identify the types of industries that might necessitate pH monitoring and control.
12. Explain how to evaluate the organic content in grit removed from a treatment plant.

**CONCEPT: TROUBLESHOOTING OF PRELIMINARY TREATMENT**

13. Outline the causes and corrective actions to control odor problems in preliminary treatment plant systems.
14. Discuss the uses, effectiveness, risks and costs of chemical odor masking agents.
15. Explain how to make use of plant records of quantity of grit removed from the system.

**CONCEPT: SAFETY IN PRELIMINARY TREATMENT**

16. Describe the safety concerns associated with the following chemicals:
  - A. Sulfuric acid
  - B. Sodium hydroxide
  - C. Potassium permanganate
  - D. Hydrogen peroxide

---

---

**MODULE D: PRINCIPLE, STRUCTURE AND FUNCTION OF PRIMARY TREATMENT**

---

---

**CONCEPT: PRINCIPLE OF PRIMARY TREATMENT**

17. Describe the affect on the various types of secondary processes caused by poor quality primary effluent.
18. Relate collection system management and enforcement of sewer use ordinances to the operation of the treatment plant.
19. Describe two characteristics of influent wastewater that may inhibit settling.

**CONCEPT: STRUCTURE AND FUNCTION OF PRIMARY TREATMENT**

20. Describe the situations when construction or operation of primary clarifiers is not necessary or advisable.
21. Compare metallic versus non-metallic chain for use in the sludge collection system of primary clarifiers.
22. Compare the discharge rate of piston pumps and centrifugal pumps at varying discharge heads.

---

---

**MODULE E: OPERATION AND MAINTENANCE OF PRIMARY TREATMENT**

---

---

**CONCEPT: OPERATION OF PRIMARY TREATMENT**

23. Describe the following types of circular clarifiers and the flow patterns used:
  - A. Center feed with rim overflow
  - B. Rim feed with rim overflow
  - C. Rim feed with center overflow



24. Explain the function of a torque limiter, and describe ways of checking to make sure it is not out of adjustment.
25. Explain how a fine screening system can be used instead of primary clarification.
26. Discuss the importance of even flow splitting to several clarifiers.
27. Discuss the possible considerations when starting a clarifier's sludge collection mechanism after a prolonged shut-down.
28. Discuss the use of chemicals to aid sludge settling.
29. Describe the methods used to determine that sufficient sludge is being pumped.

---

**CONCEPT: MAINTENANCE OF PRIMARY TREATMENT**

30. List the methods used to prevent or reduce wear on sludge collectors.
31. List the items to consider in planning routine and long-term replacement parts inventories.

---

**MODULE F: MONITORING AND TROUBLESHOOTING PRIMARY TREATMENT**

---

---

**CONCEPT: MONITORING PRIMARY TREATMENT**

32. Identify the range of sludge concentration that can be expected from a well-operated primary clarifier.
33. Identify the range of values for the following:
  - A. Detention Time
  - B. Weir Overflow Rates
  - C. Surface Settling Rates
34. Describe the concerns that can occur due to wastewater temperature changes.

35. Describe the factors to use in evaluating the operations of a primary clarifier.
36. Discuss the concerns that should be considered when accepting septage at a treatment plant

**CONCEPT: TROUBLESHOOTING PRIMARY TREATMENT**

37. Discuss how a piston pumping system can be modified to prevent damage from pumping against a closed valve.
38. Identify the causes and corrective actions for the following:
  - A. Excess Floating Scum and Grease
  - B. Floating Solids
  - C. Frequent Shearing of Pins in Collector Mechanism or Erratic Movements
  - D. Excessive Wear of Primary Chains
  - E. Hydraulic Short Circuiting
  - F. Sludge Collector Damaged Due to Excess Load
  - G. Sludge Collector Jerks and/or Jumps (No Excess Sludge Blanket)
  - H. Sludge Pump Operating, But No Sludge (Or Water) Is Being Pumped
39. List the strategies to reduce the impact of flow surges from a nearby lift station on clarifier performance.
40. Describe the affect high strength organic waste can have on primary treatment and downstream processes.
41. Describe potential symptoms and problems associated with inadequate industrial pretreatment of plating wastes.
42. Explain how denitrification (a problem usually associated with secondary clarifiers) can occur during primary clarification.
43. Describe the possible modifications to eliminate or reduce problems caused by septic primary effluent.

---

---

## MODULE G: SAFETY AND CALCULATION OF PRIMARY TREATMENT

---

---

### CONCEPT: SAFETY OF PRIMARY TREATMENT

- 44. Discuss the safety considerations in the prechlorination of influent.
- 45. Discuss the safety hazards associated with septic influent in preliminary or primary treatment.
- 46. Outline a safety and training program for employees working with preliminary and primary treatment processes.

### CONCEPT: CALCULATION OF PRIMARY TREATMENT

- 47. Given data, calculate the percent removal of BOD and Suspended Solids in a primary clarifier.
- 48. Given data relating to flows, pump capacities and solids loading to the primary clarifier, calculate the running time needed to pump sludge.
- 49. Given data related to primary clarifier loading, calculate the gallons of sludge that need to be pumped daily.
- 50. Given data, calculate the surface settling rate of a clarifier (rectangular and circular).
- 51. Given data, calculate the detention time in a clarifier (rectangular and circular).
- 52. Given data, calculate the change in volume of sludge with a change in percent solids.

## RESOURCES

1. CONTROLLING WASTEWATER TREATMENT PROCESSES. (1984). Cortinovis, Dan. Ridgeline Press, 1136 Orchard Road, Lafayette, CA 94549.
2. OPERATION OF MUNICIPAL WASTEWATER TREATMENT PLANTS. Manual of Practice No.11 (MOP 11), 2nd Addition (1990), Volumes I, II, and III. Water Environment Federation (Old WPCF), 601 Wythe Street, Alexandria, VA 22314-1994. Phone (800) 666-0206. (MOP 11, 1976 can still be used as a reference.)
3. OPERATION OF WASTEWATER TREATMENT PLANTS. 3rd Edition (1990), Volumes 1 and 2, Kenneth D. Kerri, California State University, 6000 J Street, Sacramento, CA 95819-6025. Phone (916) 278-6142.